

# Impossible outside Virtual Reality

#### Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC) Research Group

Microsoft Research June 4th 2020



https://www.microsoft.com/research/people/margon/ Twitter: @twi\_mar





# Impossible outside Virtual Reality

#### Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC) Research Group

Microsoft Research June 4th 2020



Abtahi,et al. (2019) I'm a giant: Walking in large virtual environments at high speed gains ACM CHI

https://www.microsoft.com/research/people/margon/ Twitter: @twi\_mar Let's build systems that interface with reality

GS

HC

Gonzalez-Franco, M., & Lanier, J. (2017). Model of illusions and virtual reality Frontiers in psychology, 8, 1125.



### Immersive Mixed Reality for Manufacturing Training

M Gonzalez-Franco, R Pizarro, J Cermeron, K Li, J Thorn, W Hutabarat, A Tiwari, P Bermell-Garcia



Gonzalez-Franco, Mar, et al. 2017 "Immersive mixed reality for manufacturing training." *Frontiers in Robotics and AI* 4: 3.

### FPV Drone navigation in VR



**Modified DJI S900 hexacopter (right) with the stereo camera and the Tegra TK1 embedded board attached (left)**. 28–30 frames per second encoding speed at 1,600 × 1,080 resolution per camera/eye

Smolyanskiy, N., & **Gonzalez-Franco**, **M.** (2017). Stereoscopic first person view system for drone navigation. *Frontiers in Robotics and AI*, *4*, 11.



Let's build systems that interface with reality

Gonzalez-Franco, M., & Lanier, J. (2017). Model of illusions and virtual reality Frontiers in psychology, 8, 1125.



HC

# Complex system

- Dynamic
- Priors + Pathways
- Errors + Corrections
- Concurrent stimuli of different type







### Sensory Dominance

(\*

6

**Cortical homunculus by Sharon Price-James** 

### Sensory Expertise





# Multisensory Integration



# Multisensory Integration





Nature Reviews | Neuroscience

Stein, Barry E., and Terrence R. Stanford. "Multisensory integration: current issues from the perspective of the single neuron." *Nature Reviews Neuroscience* 9.4 (2008): 255-266.

### Cognitive Latency to measure VR system latency



Gruen, Ofek, Steed, Gal, Sinclair, **M Gonzalez-Franco**\*, 2020. **Measuring System Visual** Latency through Cognitive Latency on Video See-Through AR devices. *IEEE VR*  Ø



O Sight Proprioception

https://github.com/microsoft/Microsecond-Arduino-Latency-Clock

# Visual dominance + 3D audio





#### Coordinate response measure (CRM) corpus



#### LIP CONDITIONS Synch 14 % errors Asynch 30% errors NoLips 20% errors

Gonzalez-Franco, et al. 2017 "Concurrent talking in immersive virtual reality: on the dominance of visual speech cues." *Scientific reports* 7.1: 3817.

Gonzalez-Franco, M. (2017) **Corpus Data for: "Hearing lips: on the dominance of vision in immersive cocktail party phenomena"** *Harvard Dataverse*, doi:<u>10.7910/DVN/KHXBBB</u>.

### Visual dominance Recalibration of 3D Audio



Generic HRTF might be enough in Virtual Reality.

Improving source localization through cross-modal plasticity

C C. Berger, M Gonzalez-Franco\*, A Tajadura-Jiménez D Florencio, Z Zhang

Berger, C.C., Gonzalez-Franco, M., Tajadura-Jiménez, A., Florencio, D. and Zhang, Z., 2018. Generic HRTFs may be good enough in virtual reality. Improving source localization through cross-modal plasticity. *Frontiers in neuroscience*, *12*, p.21.

### Soundscape

https://www.microsoft.com/en-us/research/product/soundscape/



#### Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues

Gregory D. Clemenson, Antonella Maselli, Alex Fiannaca, Amos Miller, Mar Gonzalez-Franco\*

Microsoft Research, margon@microsoft.com

Clemenson, Maselli, Fiannaca, Miller, Gonzalez-Franco, (in review). **Rethinking GPS Navigation: Creating Cognitive Maps Through Auditory Clues**. *PlosOne* 



### Using Voice Coil Actuators (VCA)









Perceived haptic location

we can stimulate different strengths



# **The Uncanny Valley of Haptics**

#### C C Berger, M Gonzalez-Franco\*, E Ofek, K Hinckley Microsoft Research





Berger, Gonzalez-Franco et al. (2018) The Uncanny Valley of Haptics

#### Our exploration with controllers in VR brings to the conclusion that we can reach an uncanny valley of haptics

#### SCIENCE ROBOTICS | FOCUS

#### HUMAN-ROBOT INTERACTION

#### The uncanny valley of haptics

Christopher C. Berger, \*<sup>†</sup> Mar Gonzalez-Franco, <sup>†‡</sup> Eyal Ofek, Ken Hinckley

During teleoperation and virtual reality experiences, enhanced haptic feedback incongruent with other sensory cues can reduce subjective realism, producing an uncanny valley of haptics.

Copyright © 2018 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works

#### **Observations**

### SCIENTIFIC AMERICAN

#### If (Virtual) Reality Feels Almost Right, It's Exactly Wrong

How adding touch to VR can lead to an "uncanny valley" of sensations—and what we can do about it

By Mar Gonzalez-Franco, Christopher C Berger and Ken Hinckley on April 19, 2018

.....



Let's build systems that interface with reality

GSR

Ph

Let's build systems that interface **between the brain** and reality Let's build systems that are impossible in reality

Gonzalez-Franco, M., & Lanier, J. (2017). Model of ill reality Frontiers in psychology, 8, 1125.

MD

HC

McDuff, Hurter & **Gonzalez-Franco** (2017) "Pulse and Vital Sign measurement in mixed reality using a HoloLens" ACM VRST

# Mise-Unseen

using eye tracking to hide virtual reality scene changes in plain sight

sebastian marwecki<sup>1,2</sup>, andrew d. wilson<sup>1</sup>, eyal ofek<sup>1</sup>, mar gonzalez franco<sup>1</sup>, christian holz<sup>1</sup> <sup>1</sup>microsoft research, redmond, wa, usa, <sup>2</sup>hasso plattner institute, university of potsdam, germany

# Microsoft Research

Marwecki, S, et al. "Mise-Unseen: Using Eye Tracking to Hide Virtual Reality Scene Changes in Plain Sight." *Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology*. 2019.

#### Feeling touch outside of the body



# We reproduce the cutaneous rabbit illusion in VR





Berger, C. C., & Gonzalez-Franco, M. (2018). **Expanding the sense of touch outside the body**. In *Proceedings of the 15th ACM Symposium on Applied Perception* (p. 10). ACM.



Microsoft

#### **Perceived Location of the Tap**



# Delusions of the perceptual system

- Our brain will believe the stimuli to be real when exposed to congruent inputs
- Under correct stimulation we can affect our own body experience



### Bodily illusions on avatars

Spanlang et al. (2014) *How to Build an Embodiment Lab: Achieving Body Representation Illusions in Virtual Reality* Frontiers in Robotics and AI 

# Background

#### Embodiment illusion

- Normally when we have direct control (agency) of the avatar we experience embodiment: "A 1 to 1 substitution of our body".
- Research has shown that embodiment can alter motor behavior in different ways
- Is there a common mechanism that underlies some of these motor compensations?

#### [Slater et al 2010 Siggraph]



#### Sense of Self Location

#### Sense of Agency



Gonzalez-Franco et al. (2010) The Contribution of Real-Time Mirror Reflections of Motor Actions on Virtual Body Ownership in an Immersive Virtual Environment IEEE VR



activation. Experimental Brain Research (2014)

### A threat to the Virtual Body

**Readiness Potential C3-C4** 



) Short Time Power Spectra



a) Time Frequency Evolution in C3





Gonzalez-Franco et al. A threat to a virtual hand elicits motor cortex activation. Experimental Brain Research (2014)

#### Sense of Agency







Padrao, Gonzalez-Franco et al. 2016. Violating body semantics: neural signatures of self-generated and external-errors. NeuroImage (2016)

### Disrupting the sense of agency of the VB Error Monitoring Models. Motor Control





[Gallagher 2000, Frith et al. 2000]

Padrao, Gonzalez-Franco et al. 2016. Violating body semantics: neural signatures of self-generated and external-errors. NeuroImage (2016)

### **Beyond electrophysiology: questionnaires**



https://notebooks.azure.com/margon/projects/EmbodimentQuestionnairePCA

Gonzalez-Franco M and Peck TC (2018) Avatar Embodiment. Towards a Standardized Questionnaire *Front*. *Robot*. Al

We have identified 6 main types of questions that are present depending on the experimental setup:

- 1. **Body ownership**. Present whenever there is a substitute body or body part. It is possible to have body ownership over a body that participants feel is not in the same location as their own body.
- 2. **Agency and motor control** of the body. Present whenever there is motion tracking and the participant can move parts or all of the virtual body.
- 3. **Tactile sensations**. Present whenever there is tactile or haptic stimulation to enhance the embodiment illusion.
- 4. Location of the body. Present whenever there is a substitute body or body part that is either collocated or not collocated with the participant. Participants must feel that their body is in the same location as the virtual body in order to experience an embodiment illusion. Participants may sense an out-of-body effect, or that the location of their body has drifted toward the location of the avatar. These questions are often only asked when the avatar is not collocated with the participant.
- 5. **External appearance**. Present when the self-avatar is a lookalike avatar or as control questions when there are shape, gender, race, clothing, or other visual modifications to the avatar different from the self.
- 6. **Response to external stimuli**. In many occasions during the experiment there is an event that modifies or threatens the body or body parts of the self-avatar.

Analyzed 30 famous experiments and extracted 25 questions

#### Self-avatar follower effect

We have an implicit need to fill the spatial gap between the physical and the self-avatar bodies, whenever the system allows for these types of compensation. That is the self-avatar follower effect.

down Cradual Control (Control (Contro) (Control (Contro) (Contro) (Contro

If we drift the avatar, the user will try to compensate

Gonzalez-Franco et al (2020) The Self-Avatar Follower Effect in Virtual Reality IEEE VR

### Embody avatars of different shape, size, gender etc

#### I'm a Giant: Walking in Large Virtual Environments at High Speed Gains

Parastoo Abtahi<sup>1,2</sup>, Mar Gonzalez-Franco<sup>1</sup>, Eyal Ofek<sup>1</sup>, Anthony Steed<sup>1,3</sup> <sup>1</sup>Microsoft Research, <sup>2</sup>Stanford University, <sup>3</sup>University College London



Abtahi, et al. (2019) I'm a giant: Walking in large virtual environments at high speed gains ACM CHI

#### Embodiment in Robots



#### Kishore, Gonzalez-Franco et al. MIT Presence Teleoperators (2014)

#### Embodiment increases haptic experiences



**Confidence on the Out-of-Body Touch Illusion**. IEEE Transactions on Haptics

### Many Individual Differences In Embodiment across participants



Embodied Distance Estimation in Virtual Reality IEEE VR



#### Self-recognition on Avatars

**Gonzalez-Franco** et al. 2016. The neurological traces of look-alike avatars Frontiers in Human Neuroscience

#### A Avatar creation





**B** Experimental Execution

resting period every 10 faces + face x 200 + fixation cross - fixation cro



#### Self-recognition on Avatars



#### Fast Adaptative Effects in Virtuality (PO7,P7)



**Gonzalez-Franco** et al. 2016. The neurological traces of look-alike avatars Frontiers in Human Neuroscience

#### Enfacement on Avatars



Gonzalez-Franco et al. 2020 Using Facial Animation to Increase the Enfacement Illusion and Avatar Self-Identification. IEEE VR. IEEE Transactions on Visualization and Computer Graphics



#### **Enfacement on Avatars**



IEEE Transactions on Visualization and Computer Graphics

# Avatar BEHAVIOUR



Sanchez-Vives & Slater Nat Neurosci 2005

Moohan at al Siggraph 2002

Nature Reviews | Neuroscience

### SCIENTIFIC AMERICAN

#### Would You Give a Virtual Electric Shock to an Avatar?

In a repeat of a classic experiment, we find that people who are only unenthusiastically obeying unethical orders still experience trauma

By Mar Gonzalez-Franco, Mel Slater on April 12, 2019

.....

One common trait of repressive governments or laws is the emergence of an organized resistance, often involving high-ranking officials and civil figures who aren't keen on obeying their leaders.

clear evidence of a kind of disobedience among our participants. They did not enter an "agentic" state, blindly and carefully carrying out the orders of the experimenter, as executioners of harmful behavior. Instead they fit more the profile of an "engaged follower," someone who apparently engages but nevertheless tries to get around the specifics of the orders. Essentially, they were disobeying or quietly resisting while appearing to follow orders.



### Participant concerns for the Learner in a Virtual Reality Replication of a Milgram Obedience Study

Gonzalez-Franco, M., Slater, M., Birney, M., Swapp, D., Haslam, S.A. & Reicher, S.D.

Gonzalez-Franco et al. 2019 Participant concerns for the Learner in a Virtual Reality replication of the Milgram obedience study. Plos One

### Virtual Reality Makes Avatars More Important Than Ever

Immersing yourself in an alternative universe is VR's selling point. But how do the avatars that populate these worlds impact our experiences and our behaviour?

By Emily Reynolds

Dec 11 2016, 1:00pm 🖪 Share 🎔 Tweet 🌲 Snap



# Microsoft Rocketbox

library of rigged avatars free for academic and research use



#### https://github.com/microsoft/Microsoft-Rocketbox

Gonzalez-Franco, Ofek, Pan, Antley, Steed, Spanlang, Maselli, Banakou, Pelechano, Orts Escolano, Orvahlo, Trutoiu, Wojcik, Sanchez-Vives, Bailenson, Slater, and Lanier. Frontiers in VR (in review) "Importance of rigging for procedural avatars. Microsoft Rocketbox a public library."

### **Thanks!**

#### Microsoft Research





**Ken Hinckley** 



**Mike Sinclair** 





**Amos Miller** 







**External Collaborators** 



Laura Trutoiu



**Mel Slater** 

**Max Di Luca** 

Ana Tajadura, Zhengyou Zhang, Dinei Florencio, Nikolai Smolyanski, Antoni Rodrigez-Fornells, Dalila Bourin, Domna Banakou, Nuria Pelechano, Sergio Orts, Ye Pan, Bernhard Spanlang, Daniel Perez Marcos, Bigna Lenggenhager





**Christopher Berger** 



Interns



Parastoo Abtahi

**Gregory Dane** Clemenson



**Brian Cohn** 

Baihan Lin, Rob Kovacs, Karan Ahuja, Sebastian Marwecki, Ryo Suzuki



**Jaron Lanier** 









**Jaeyeon Lee** 









# Impossible outside Virtual Reality

#### Dr. Mar Gonzalez-Franco

Extended Perception, Interaction & Cognition (EPIC) Research Group

Microsoft Research June 4th 2020



https://www.microsoft.com/research/people/margon/ Twitter: @twi\_mar